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VITAMINS FOR SWINE

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A. Vitamins needed in swine diets

Pigs require vitamins in much smaller amounts than other nutrients because they do not use vitamins as an energy source or as a structural component. A pig's requirement for different vitamins varies depending on the ability of the animal to produce and store the vitamin.

Some vitamins can be produced within the pig's body in sufficient quantities to meet its needs (e.g. vitamin C). Others are present in adequate amounts in feeds commonly used in swine diets. Several vitamins should, however, be added to swine diets to obtain optimal performance. The trend away from pasture towards confinement rearing and the use of simpler diets containing fewer ingredients has made vitamin supplementation for pigs much more important.

Vitamins are classified as either water soluble or fat soluble. The fat soluble vitamins can be stored in body tissues and do not have to be provided every day in the diet. These are vitamins A, D, E and K. The water soluble vitamins are not stored in the body and must be provided daily in the diet. These are the B complex vitamins and include riboflavin, niacin, pantothenic acid, B12, thiamine, biotin, pyridoxine and folic acid.

Vitamin levels are usually expressed in terms of International Units (IU). This is an arbitrary term which allows comparison of specific vitamin levels in different feeds. International Units are defined differently depending on the vitamin.

Each vitamin is discussed below. A brief description of its function in the body and deficiency/toxicity symptoms are included.

Vitamin A

Vitamin A is important for proper vision, bone development, reproduction and in the formation of mucous membranes (e.g. the lining of the lungs and intestine).

Vitamin A is present in plants in the form of carotene. The carotene is converted to vitamin A in the intestinal wall of the pig. Fish oils and alfalfa

meal are good natural sources of carotene. Yellow corn contains carotene but most of this is destroyed during storage. Cereal grains are very poor sources of carotene.

Vitamin A is added to swine feed in the forms of vitamin A palmitate or vitamin A acetate, both of which are very stable. However, close contact with trace minerals and/or unstable fats will increase destruction of the vitamin. Premixes containing vitamin A and trace minerals can be stored for up to four months without a significant loss in activity. During storage the premix should be kept dry and not exposed to heat or light.

Deficiency symptoms — Symptoms of a vitamin A deficiency include night blindness, lack of coordination and paralysis. Sows may experience anestrus and poor conception rates. Piglets may be born dead, weak or malformed (cleft palate, hydrocephalus and small or no eyes). Sterility may occur in boars.

Toxicity — Toxic symptoms are extremely uncommon and only occur if excessive levels of vitamin A are fed for a prolonged period. Symptoms include a roughened hair coat, blood in urine and feces, bleeding from cracks around hooves, tremors and death. These symptoms have been observed in young pigs (5 - 10 kg) fed 880,000 or 440,000 IU of added vitamin A/kg of diet for 18 and 43 days, respectively. No toxicity signs were observed when pigs were fed 220,000 IU of added vitamin A/kg of diet for 56 days.

Vitamin D

Vitamin D is required for efficient absorption and metabolism of calcium and phosphorus. As a result it is important in normal bone formation and metabolism.

Pigs can synthesize vitamin D when exposed to sunlight. Pigs housed indoors will require vitamin D supplements in their diet. Fish oils are a good source of the vitamin, whereas cereal grains contain no vitamin D. Pigs housed indoors will require vitamin D supplements in their diet.

Vitamin D_3 (cholecalciferol) is the primary form in which vitamin D is added to diets. Although it is a slightly more stable compound than vitamin A, care should still be taken to store it properly in a cool, dry, dark area.

Deficiency symptoms — Symptoms include rickets in young pigs, stiffness and lameness, joint enlargement and osteomalacia and bone fractures in older pigs.

Toxicity — Excessive levels of vitamin D have been shown to be harmful. Calcification of the kidney, heart and lung can lead to death. Levels of 473,000 IU vitamin D_3/kg diet have been shown to cause death to 20 - 25 kg pigs within 4 days. Lower levels (22,000 IU/kg diet) may cause a reduction in daily gain and feed efficiency.

Vitamin E

Vitamin E is a general name for a group of compounds called tocopherols and tocotrinols. They are required for normal muscle activity, reproduction, production of various hormones and in the body's defense against infection. Vitamin E is an antioxidant and as such protects cell membranes from deterioration.

Vitamin E is present in many feedstuffs but is destroyed by storage and the artificial drying of grains. A common form of supplementation is with the acetate forms of alpha-tocopherol. Alpha-tocopherol is the most active component of vitamin E and the acetate form is the most stable. Vitamin E is generally unstable especially in the presence of rancid fats. It is also much more expensive than vitamins A and D, so overformulation of diets is not common.

When ensuring that diets contain adequate levels of vitamin E, it is essential that the level of selenium be taken into consideration. Vitamin E and selenium work together in preventing deficiencies of one or the other nutrient. If one nutrient is deficient in the diet the requirement for the other is raised. Conversely a high dietary level of one reduces but does not eliminate the need for the other.

Deficiency symptoms — Symptoms include mulberry heart disease, sudden death and white muscle disease (muscle degeneration). There is some evidence that a vitamin E deficiency may be involved with MMA (mastitis - metritis - agalactia). Because sows can store considerable quantities of vitamin E for long periods of time, the effect of a vitamin E deficiency on reproduction is hard to document.

Toxicity — A vitamin E toxicity has not been demonstrated in swine. Levels as high as 100 IU/kg of diet have been fed to growing pigs without any toxic effects.

Vitamin K

Although vitamin K was the last of the four fat soluble vitamins to be discovered, its metabolic role is the most clearly defined. It is essential for the

synthesis of prothrombin and three other factors which are necessary for the normal clotting of blood. Vitamin K is also involved in calcium and vitamin D metabolism.

It is found in many natural feedstuffs (especially alfalfa meal) and is also synthesized by the intestinal microflora of the pig. In spite of this, a deficiency may occur and is associated with the feeding of moldy feeds. The use of sulpha drugs may reduce bacterial synthesis, placing greater importance on dietary sources of vitamin K. Menadione, the synthetic form of vitamin K, is usually added to swine feeds.

Deficiency symptoms — Symptoms of a vitamin K deficiency are hemorrhaging (both internal and external), prolonged blood clotting time, blood-tinged urine, lameness and listlessness.

Toxicity — A toxic level of vitamin K has not been determined.

Riboflavin

Riboflavin is a component of several enzymes which are involved in protein, fat and carbohydrate metabolism. It is also important for the proper development of the fetus.

Cereal grains and plant by-products, such as soybean meal, are relatively poor sources of riboflavin. Whey powder is the only ingredient used in pig diets which is a good source of this B vitamin. Because of this, riboflavin is routinely added to all swine diets.

Deficiency symptoms — Symptoms include stiffness, loss of appetite, reduced growth rate, cataracts, anestrus in gilts and birth of deformed piglets.

Niacin

Niacin (or nicotinamide) is involved in the metabolism of many dietary components including fats, carbohydrates and proteins.

Although niacin is present in adequate amounts in most cereal grains, it usually exists in a form that is largely unavailable to the pig. The niacin found in soybean meal is, however, highly available. Alfalfa meal is another good natural source of niacin. A synthetic form of niacin is readily available and is routinely added to swine diets.

The amino acid, tryptophan, can act as a precursor for niacin. Diets containing excess tryptophan reduce the need for niacin while diets marginal in tryptophan will increase the need for dietary niacin. In corn-based diets where tryptophan is the second limiting amino acid, it is unlikely that dietary tryptophan will provide appreciable amounts of niacin.

Deficiency symptoms — Symptoms include slow growth, diarrhea, dry skin, dermatits, loss of hair and vomiting.

Pantothenic Acid

Pantothenic Acid is a component of an enzyme involved in carbohydrate and fat metabolism. It is found in many feed sources. High levels of available pantothenic acid are found in bean meal. In spite of this, cereal based diets are usually supplemented with a synthetic form of the vitamin. Corn and sorghum have low levels of available pantothenic acid.

Deficiency symptoms — Deficiency symptoms include reduced growth rate, diarrhea, rough hair coat and an uncoordinated, wobbly or high-stepping gait called goose stepping.

Vitamin B_{12} (Cyanacobolamine)

Vitamin B_{12} is unique among vitamins in that it contains the trace mineral cobalt in its structure. It is also required in minute amounts compared to the other B vitamins. Vitamin B_{12} is involved in protein metabolism.

Grains and other plant products do not contain any vitamin B_{12}, but it is found in animal by-products. It is synthesized by micro-organisms in the intestinal tract and in the environment. Pigs with access to feces may obtain sufficient vitamin B_{12} from this source to satisfy their requirement. Synthetic vitamin B_{12} is usually supplemented in swine diets.

Deficiency symptoms — Symptoms include anemia, a rough hair coat and poor coordination of the hind legs. A long term deficiency may result in nerve degeneration. A severe deficiency can result in high mortality among young pigs.

Biotin

Biotin is involved in many aspects of fat, carbohydrate and protein metabolism. It also plays a role in the maintenance of hair, skin, nerves and sex glands.

Biotin is present in most common feedstuffs in adequate amounts, but its availability varies greatly among ingredients. The availability in cereal grains is generally low. The biotin in corn, soybean meal and canola meal is more highly available.

Although there is considerable controversy over the need for supplemental biotin, barley and wheat based diets are usually supplemented with 150 to 250 micrograms of biotin per kg of diet especially in rations for the breeding herd and replacement gilts and boars. Much higher levels are sometimes supplemented but the benefits are questionable. Biotin is an expensive vitamin and therefore, excessive safety margins are of little or no economic benefit.

In general, research has shown that the performance of weanling and growing-finishing pigs is not improved with biotin supplementation.

Deficiency symptoms — Symptoms include excessive hair loss, skin ulcerations, dermatitis and cracked hooves, which can lead to premature lameness.

Thiamine

Thiamine is required by pigs for proper energy metabolism. Most common feed ingredients (cereal gains, bran, etc.) are good sources of thiamine and diets are generally not supplemented. Occasionally starter diets may contain small amounts of additional thiamine (1 mg/kg). There is little information on the thiamine requirement of pregnant and lactating sows.

Deficiency symptoms — Symptoms include loss of appetite, reduced body temperature and vomiting.

Pyridoxine

Pyridoxine is a component of over 50 enzymes that are involved in amino acid metabolism and the central nervous system.

Supplementation of grain-soybean meal diets is generally unnecessary because of the high concentration and availability of pyridoxine in feed ingredients. Starter diets are sometimes supplemented with the vitamin.

Deficiency symptoms — Symptoms are reduced appetite and growth rate. An advanced deficiency can result in convulsions and death.

Folic Acid (Folacin)

Folic acid is involved in cell division and growth and in amino acid metabolism.

Research indicates that the folic acid in feed ingredients combined with bacterial synthesis of the vitamin in the intestinal tract meet the requirement for most classes of swine. There is limited evidence which suggests that the reproductive performance of sows may be improved by folic acid supplementation. Sulfa drugs act to reduce bacterial synthesis of folic acid.

Deficiency symptoms — Symptoms include fading hair color, anemia and reduced weight gains.

Vitamin C (Ascorbic Acid)

Most animals are capable of synthesizing enough vitamin C to meet their own requirement. Pigs can convert glucose to vitamin C to meet their requirement. There has been some suggestion that young pigs and pigs exposed to environmental stresses may benefit from vitamin C supplementation. The available information is not conclusive.

Choline

Choline does not qualify as a true vitamin because it is required at levels far greater than those of other vitamins and it is not known to participate in any enzyme systems. Choline is a component of phospholipids which are essential for cell membrane structure and nervous system function. It is also involved in fat metabolism and in the synthesis of the amino acid glycine.

Choline is available to the pig through feed ingredients and through internal synthesis from the amino acid methionine.

A choline deficiency has been implicated as a cause of spraddle leg but there is little or no scientific research to back this up. Choline is expensive and other more effective solutions to the problem should be considered (good flooring material in crates, tracing genetic predisposition in the breeding herd).

Deficiency symptoms — Symptoms include reduced weight gain, rough hair coats, anemia and unbalanced, staggering gaits.

B. Identifying vitamin deficiencies

Diagnosing vitamin deficiencies is not a simple task. Symptoms are rarely specific and few deficiences can be identified by a single symptom. To ensure an accurate diagnosis of a vitamin deficiency it is important that symptoms be considered along with herd history, a review of the herd health status and an evaluation of the rations being fed. See Table 1. Swine Vitamin Chart (from NRC, 1988)

C. Vitamin stability

(Reprinted from *Swine Nutrition Guide*, University of Saskatchewan)

Vitamin supplements deteriorate with age and certain environmental factors increase this rate of breakdown. Agents that tend to stimulate degradation of vitamins include moisture, oxygen (air), light, heat and acids. Another concern is pH, but there is little the producer can do to regulate it, for it is the responsibility of the feed supplier. A producer must be aware of those situations that increase vitamin breakdown in order to avoid them as much as possible. In general, the fat soluble vitamins are less stable than the water soluble vitamins. There are exceptions, though. For example, vitamin C is very unstable in the diet.

The manufacturers of vitamin supplements have recognized the problem of stability. Vitamins A, D and E are supplied encased in beadlets of gelatin that protect them from breakdown but which still allow for absorption in the gut. These gelatin beadlets also contain antioxidants which provide further protection for the vitamins inside.

The presence of trace minerals such as copper and iron in the diet tend to increase the breakdown of some vitamins. Poor quality fats may also cause a problem. The concern regarding trace minerals is greater in premixes than complete feeds since in a premix, trace minerals are present in much higher relative concentrations and are thus in more intimate contact with vitamins.

Choline chloride is a particular stress factor for vitamin A. Breakdown can be as much as three to four times higher in premixes containing choline chloride than those without it.

A premix containing only vitamins can be stored for up to six months with minimal deterioration, the one exception being folic acid. Vitamin-trace mineral premixes, sometimes called micro-premixes, which do not contain calcium, phosphorus or salt, can be stored for up to four months. However, losses of some vitamins under good storage conditions will approach 10 per cent. Folic acid and vitamin C, if present, are the least stable vitamins in such premixes.

Macro-premixes which contain supplements of all vitamins and mineral (micro and macro-minerals) should not be stored for more than 4 months, since losses in excess of 10 per cent can occur for many vitamins including A, D, K, thiamine, pantothenic acid, folic acid and vitamin C.

To ensure maximum vitamin stability, premixes should be in a cool, dry dark location and inventories should be turned over as quickly as possible. This is particularly true in the summer when temperature and humidity are higher.

Complete feeds normally should not be stored for more than four months. Longer storage can result in vitamin losses of 10 per cent or more, with vitamins C and K and folic acid most likely to be affected.

The acceptable storage period can be increased if extra vitamins are added. By providing large overages, shelf-life can be extended because losses due to storage will be offset by higher original concentrations of the vitamins.

Table 1. Swine vitamin chart (from N.R.C. 1988)

Vitamin	Clinical signs of deficiency	Main sources for feed use
A	Incoordination of movement Head tilted Paralysis of rear limbs Night blindness Congenital defects Slow growth	Synthetic form Fish liver oils Carotene (pro-Vit A) Supplied by: green, leafy feeds, dehydrated alfalfa meal, corn, etc.
D	Slow growth Weakened bones Lameness, stiffness	Synthetic form Fish liver oils Irradiated yeast
E	Edema Sudden death White muscles Mulberry heart disease	Synthetic form Plant germ, germ oils Grains

Table 1. (con't)

Vitamin	Clinical signs of deficiency	Main sources for feed use
K	Pale newborn pigs with loss of blood from umbilical cord Generalized hemorrhage Prolonged blood clotting	Synthetic form Animal by-product meats Dehydrated alfalfa meal
Thiamin	Poor appetite Poor growth Sudden death	Synthetic form Dehydrated alfalfa meal Grains Plant proteins Yeast
Riboflavin	Poor growth Reduced appetite Poor hair and skin condition Lameness and stiffness Diarrhea Impaired sow reproductivity	Synthetic form Dehydrated alfalfa meal Animal by-product meals Plant proteins (some) Yeast Milk products Distillers dried solubles
Niacin	Poor appetite Poor growth Diarrhea Dermatitis	Synthetic form Animal by-product meals Dehydrated alfalfa Distillers dried solubles Yeast
Biotin	Spasticity of hind legs Hoof cracks Dermatitis and hair loss Poor growth Lower fertility	Synthetic form Animal by-product meals Plant proteins Distillers dried solubles Yeast
Choline	Slow growth Reduced litter size Spraddle-legs in piglets	Synthetic form Animal by-product meals Plant proteins Distillers dried solubles Dehyrated alfalfa meal Distillers dried solubles
Pantothenic Acid	Poor appetite Poor growth Diarrhea Unusual walk (goose-stepping) Impaired sow reproductivity	Synthetic form Plant proteins Dehydrated alfalfa meal Fish solubles Yeast
B_{12}	Poor growth Reduced appetite Hypersensitivity Anemia	Synthetic form Animal by-product meals Milk products

Table 2. Vitamin requirements of swine (amount[1]/kg diet) (Nutrient Requirements of Swine, 1988)

	Growing - finishing swine (liveweight, kg)[2]					Bred gilts, sows and adult boars[3]	Lactating gilts and sows[4]
	1-5	5-10	10-20	25-50	50-110		
Nutrient/Units							
Vitamin A (IU)	2,200	2,200	1,750	1,300	1,300	4,000	2,000
Vitamin D (IU)	220	220	200	150	150	200	200
Vitamin E (IU)	16	16	11	11	11	22	22
Vitamin K (mg)	0.5	0.5	0.5	0.5	0.5	0.50	0.50
Bioton (mg)	0.08	0.05	0.05	0.05	0.05	0.20	0.20
Choline (g)	0.6	0.5	0.4	0.3	0.3	1.25	1.00
Folic acid (mg)	0.3	0.3	0.3	0.3	0.3	0.30	0.30
Niacin, available (mg)	20.0	15.0	12.5	10.0	7.0	10.00	10.00
Pantothetic acid (mg)	12.0	10.0	9.0	8.0	7.0	12.00	12.00
Riboflavin (mg)	4.0	3.5	3.0	2.5	2.0	3.75	3.75
Thiamine (mg)	1.5	1.0	1.0	1.0	1.0	1.00	1.00
Vitamin B_6 (mg)	2.0	1.5	1.5	1.0	1.0	1.00	1.00
Vitamin B_{12} (mcg)	20.0	17.5	15.0	10.0	5.0	15.00	15.00

[1] IU - International Units
mg - milligrams
g - grams
mcg - micrograms

[2] Based on ad libitum feeding
[3] Based on a daily feed intake of 1.9 kg
[4] Based on a daily feed intake of 5.3 kg

Table 3. Average vitamin content of feed ingredients (mg/kg) commonly used in swine diets on an as fed basis (Nutrient Requirements of Swine, 1988)

	E	Biotin	Choline	Folic acid	Niacin	Pantothenic acid	Riboflavin	Thiamine	B_6	B_{12}
Barley	22.0	0.15	1,036	0.6	76	7.9	1.6	4.5	5.8	-
Wheat	11.1	0.11	1,004	0.4	53	10.1	1.3	4.5	3.0	-
Corn	20.9	0.07	504	0.3	23	5.1	1.1	3.7	6.2	-
Oats	14.9	0.27	967	0.4	14	7.8	1.4	6.0	2.5	-
44% Soybean Meal	2.4	0.32	2,609	0.6	28	16.3	2.9	6.0	6.0	-
47.5% Soybean Meal	3.3	0.32	2,753	0.7	22	14.8	2.9	3.1	4.8	-
Canola Meal	-	0.90	6,700	2.3	160	9.5	3.7	5.2	-	-
Field Peas	3.0	0.18	547	0.2	31	18.7	1.8	4.6	2.0	-
Alfalfa Meal	111.0	0.33	1,369	4.4	37	29.7	12.9	3.4	7.2	-
Bran	14.3	0.38	1,232	1.8	197	28.0	3.6	8.4	10.3	-
Beet Pulp	-	-	820	-	17	1.4	0.7	0.4	-	-
Dried Skim Milk	9.1	0.33	1,394	0.6	11	36.4	19.1	3.7	4.1	0.051
Dried Whey	0.2	0.35	1,790	0.9	11	46.2	27.4	4.0	3.2	0.019
Fish Meal (herring)	22.1	0.49	5,266	0.3	85	17.3	9.7	0.4	4.6	0.430

Note: A dash (-) indicates that the feed does not contain the particular vitamin.

Table 4. Suggested vitamin supplementation levels for swine feed (per kg)

Creep and	Grower and starter	Dry sow and finisher	Nurse sow
Nutrient/Units		<------ Per Kilogram of Diet ------>	
Vitamin A (IU)	7500	5000	7500
Vitamin D (IU)	500	500	1000
Vitamin E (IU)	40	40	60
Vitamin K (mg)	2	2	2
Vitamin B 12 (mcg)	30	25	25
Riboflavin (mg)	12	12	12
Niacin (mg)	40	30	30
Panto (mg)	25	20	20
Choline (mg)	600	300	600
Biotin (mcg)	250	0	250
Folic acid (mcg)	200	0	200

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